WFIRST Observing Plan Update

C Hirata

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Outline

1. Introductory Reminders/Questions
2. New Constraints in AFTA vs DRM1/2
3. Updated Planning Tools
4. Example Observing Sequences
5. Audience Participation

What did we present last time?

- Existence proof strategy for DRM1 with health warning (explicitly not a recommendation).
- Constraints of each program and of the observatory. For GO we said: "*The GO program uses time not allocated to other programs, and has a requirement of ≥10% of the total observing time. All celestial objects must be accessible at some point during the GO period.*"
- Observing sequence + charts (sun angle, survey footprint, distribution of sky brightnesses).
- Separate section gave deltas for DRM2 (including charts).

Key Issues where your input is needed

1. Do we keep the same format?
2. Should we just show one plan, assuming the coronagraph?
   - Jeremy Kasdin and I need to make this consistent.
3. Especially now on AFTA, should the example explicitly show more GO time?
   - Experience: No matter how many health warnings I give, many members of the community will assume the GO program will only go down.
   - How should we account for the constraints on the GO program?
4. Should the reference survey footprint be moved entirely to the southern hemisphere?
   - Even if we have to accept higher background levels to get to ~2000 deg^2?
5. Any key figures that we should make.

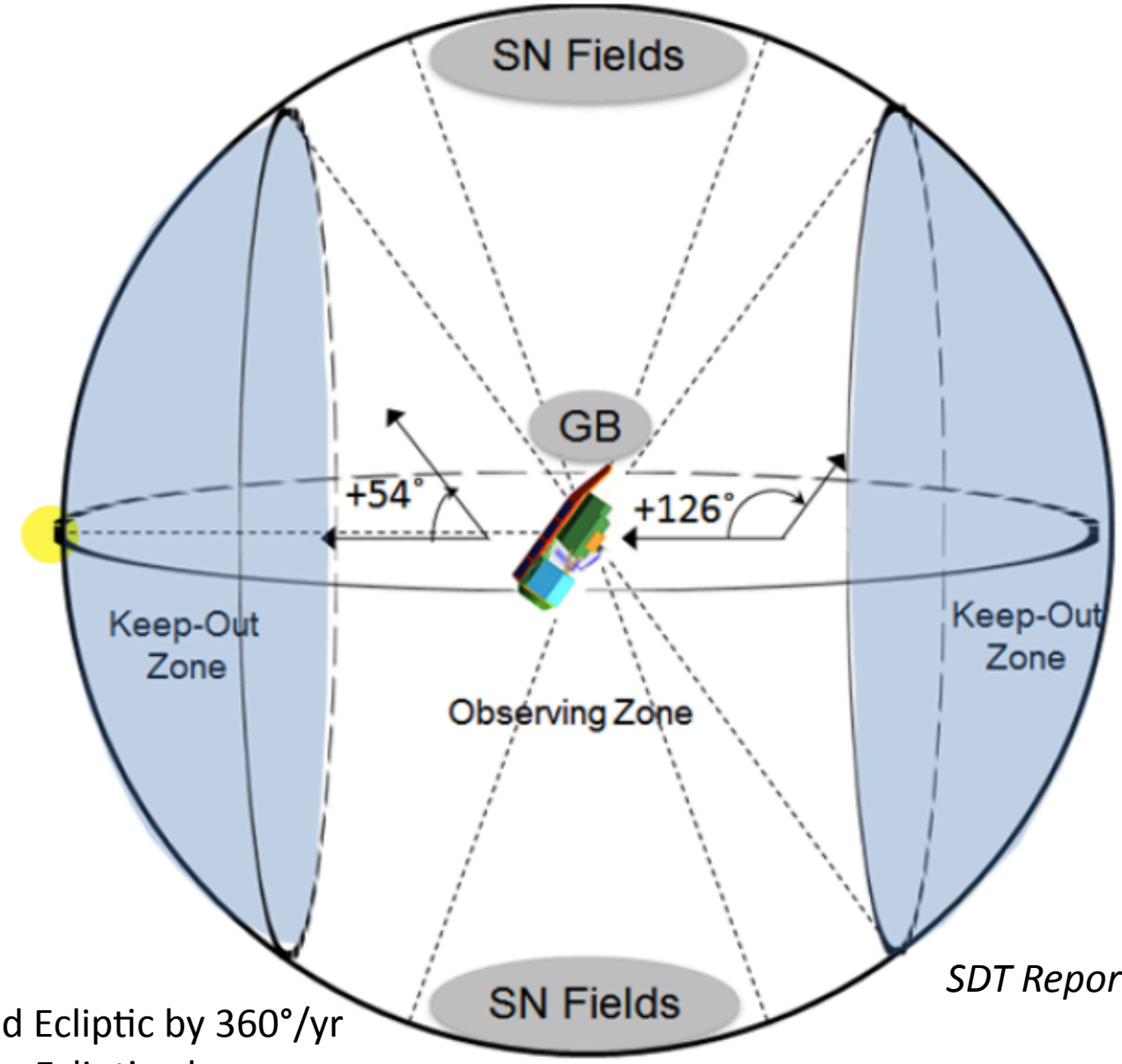
WFIRST Programs

- Requirement is to plan 5—6 programs –
  - ① High Galactic latitude survey (HLS)
    - Both imaging & spectroscopy included
  - ② Supernova (SN) survey – near an Ecliptic pole
  - ③ Microlensing (μL) – in Galactic bulge
  - ④ Galactic Plane survey (GPS) – at $b \sim 0°$, $l = 0—360°$
  - ⑤ Guest observer (GO) – target fields, revisits/cadence TBD
- For AFTA, we will also consider:
  - ⑥ Coronagraph (not in this presentation)
- The constraints for these programs are more than just adding up mission time.
  - We need an "existence proof" plan (to be refined later).
  - **Treat all programs as equal priority for this exercise**, but the observing plan first schedules the observations whose constraints are "hard."

New Constraints

- AFTA-WFIRST plans to use a different orbit
  - We are in 28.5° inclination GEO instead of L2.
- Major implications for scheduling:
  - Earth avoidance constraints (1 day cycle)
  - Moon avoidance (1 month)
  - Eclipses – impact TBD.
    - I scheduled WL observations avoiding the eclipse seasons.

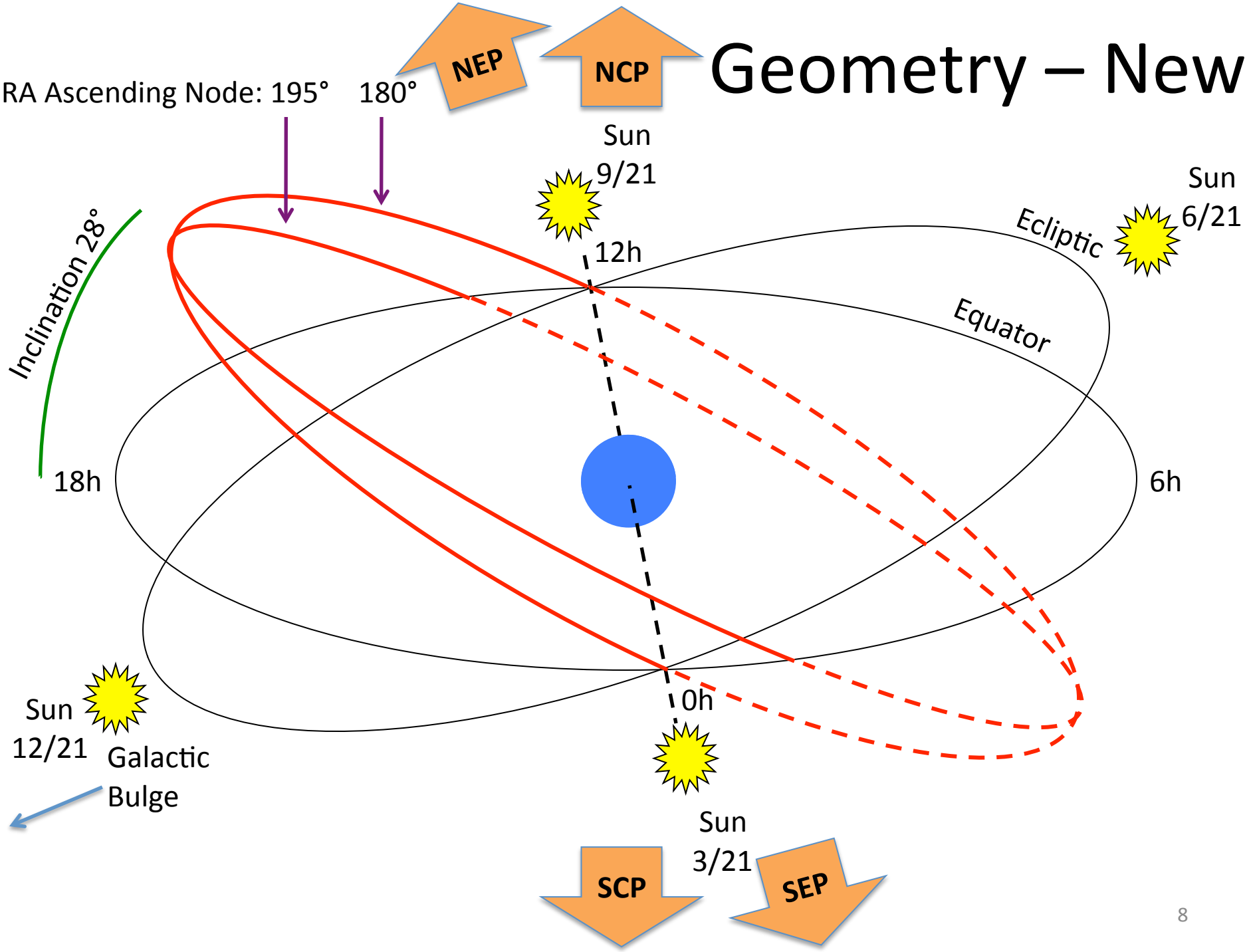
Geometry – Old



SDT Report, Figure 41

- FoR rotates around Ecliptic by 360°/yr
- Galactic bulge near Ecliptic plane

Geometry – New



Constraints

- Sun angle constraints
  - Angle from boresight to Sun: 54—126°
  - Roll angle limits ±10° or ±22.5° depending on elongation.
  - Center of allowed roll angles biased by −35°.
- Earth and Moon constraint angles are TBD.
  - Here assumed 30° from limb – note Earth radius from GEO is 9° so effective Earth constraint is 39°.
- Slew-settle times from formula provided by Eric Stoneking

Comments

- Moon constraint impacts –
  - No significant impact on HLS or SN (far from Ecliptic)
  - Minor for Galactic plane – observations can be rescheduled
  - ~4.5 day cutout each month in microlensing
- Earth constraint impacts –
  - At inclination 28°, no cutout for microlensing
  - Ecliptic poles not accessible at extreme N or S limit of orbit. The SN fields are biased away from poles to avoid the cutout.
  - Forces global balance of programs, e.g. N vs S, distribution of RA.

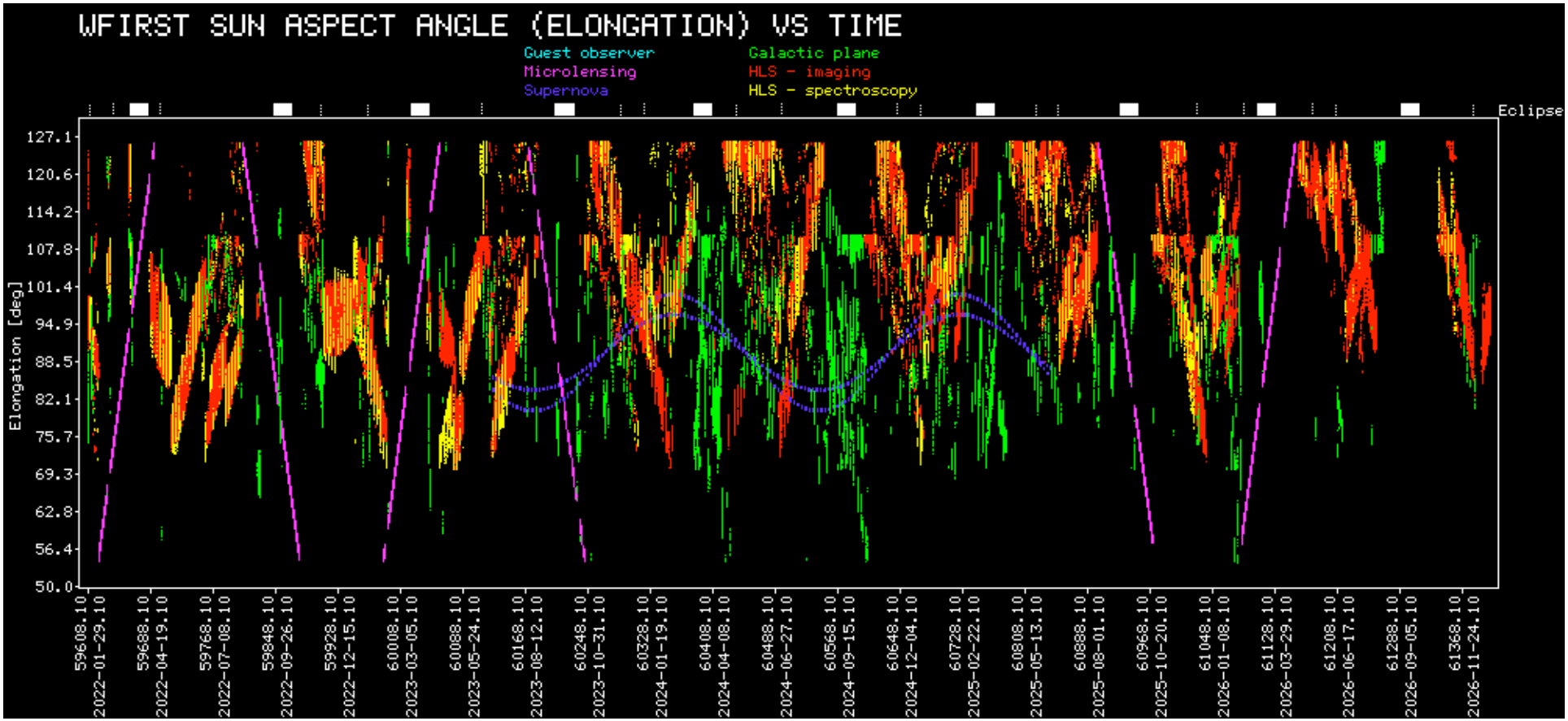
Assumed Orbit

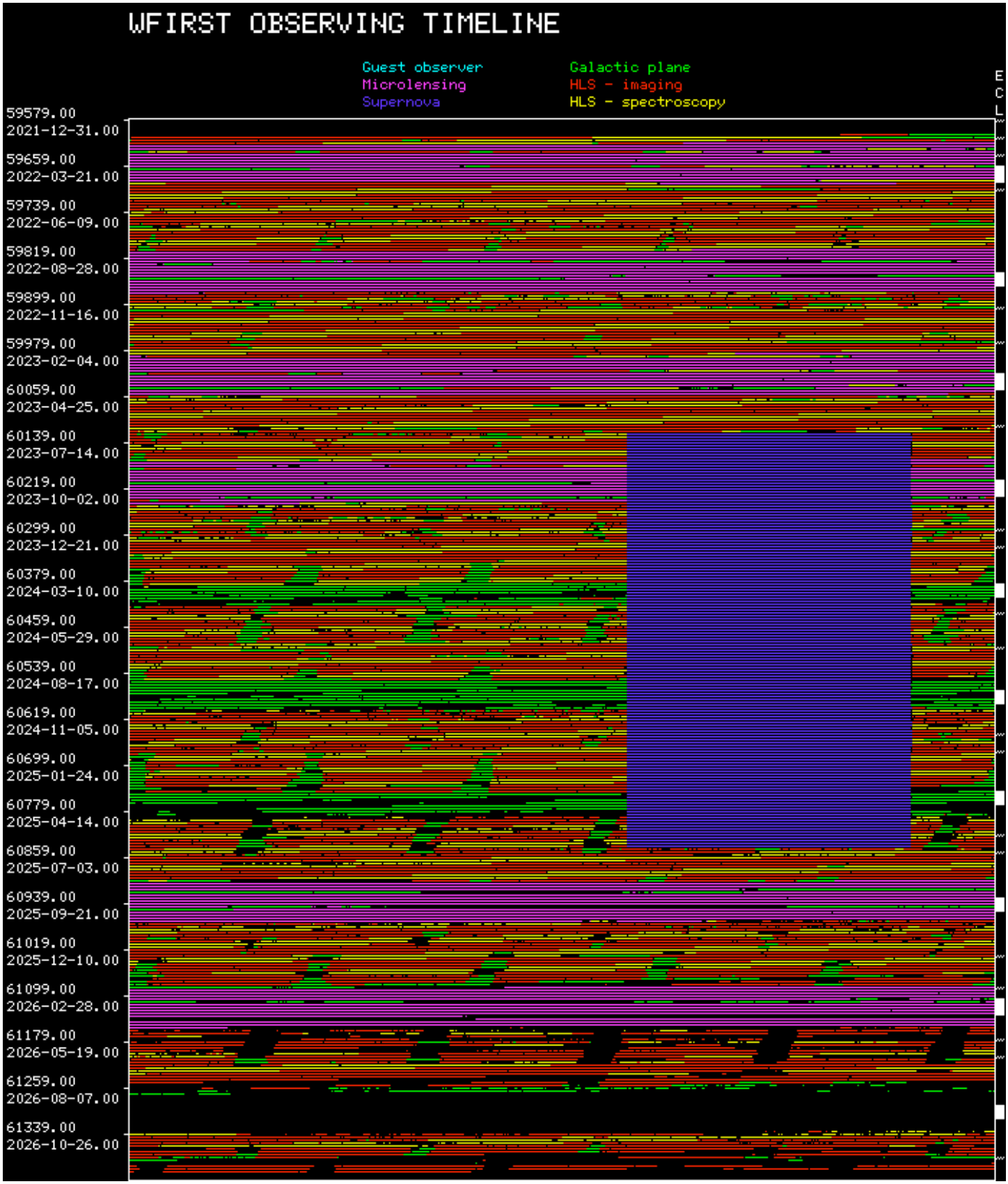
- Sun, Moon constraints based on position from JPL – Horizons
- Initial circular GEO @ i = 28.5°, Ω = 205°, assumed start date 12/31/2021
- Spacecraft orbit integrated using Sun & Moon perturbations + Earth multipoles through L=4
    - Should be good enough for purpose of establishing consistency of observing programs. At some point want to do this "right" (with realistic distribution of station keeping maneuvers, etc. – not this study).
    - Assumed 105° W longitude (libration point). Other choices would not substantially affect the observing plan (observing plan shifted by 4 min per degree; may have different lunar cutouts).
  - Main effect for our purposes is precession: RA of ascending node decreases, dΩ/dt ~ −7 deg/yr (both Earth quadrupole and external torque significant)
  - Started at Ω=205°, precesses to 171° over 5 years.
    - Ideal for microlensing is ~180°.

One Example Shown

- Linked HLS imaging + spectroscopy
- Similar time breakdown to previous DRMs
- GO program is "unallocated" – i.e. I left some free time, need to revisit to ensure availability of all targets
- Some minor issues, easy to fix by March (or in some cases leave as liens)
  - Microlensing program 1 season short of maximum baseline (4.2 vs 4.7 years)
  - Current program is fragmented – leads to inefficiencies
  - SN currently scheduled in prism mode, switch to IFU
  - Tiling constraints for photo-z calibration of IFU
  - Scheduling of microlensing observations during retrograde motion
- Also need to include allocation for calibration observations – you **will** be taxed (I didn't sign the pledge).
- Balance of programs needs discussion, even though this is only notional.
- Other cases in the works
  - This one started working Tues 1/8

The Plan – Elongation Plot




WFIRST OBSERVING TIMELINE
Guest observer
Microlensing
Supernova
Galactic plane
HLS - imaging
HLS - spectroscopy
ECL
59579.00
2021-12-31.00
59659.00
2022-03-21.00
59739.00
2022-06-09.00
59819.00
2022-08-28.00
59899.00
2022-11-16.00
59979.00
2023-02-04.00
60059.00
2023-04-25.00
60139.00
2023-07-14.00
60219.00
2023-10-02.00
60299.00
2023-12-21.00
60379.00
2024-03-10.00
60459.00
2024-05-29.00
60539.00
2024-08-17.00
60619.00
2024-11-05.00
60699.00
2025-01-24.00
60779.00
2025-04-14.00
60859.00
2025-07-03.00
60939.00
2025-09-21.00
61019.00
2025-12-10.00
61099.00
2026-02-28.00
61179.00
2026-05-19.00
61259.00
2026-08-07.00
61339.00
2026-10-26.00

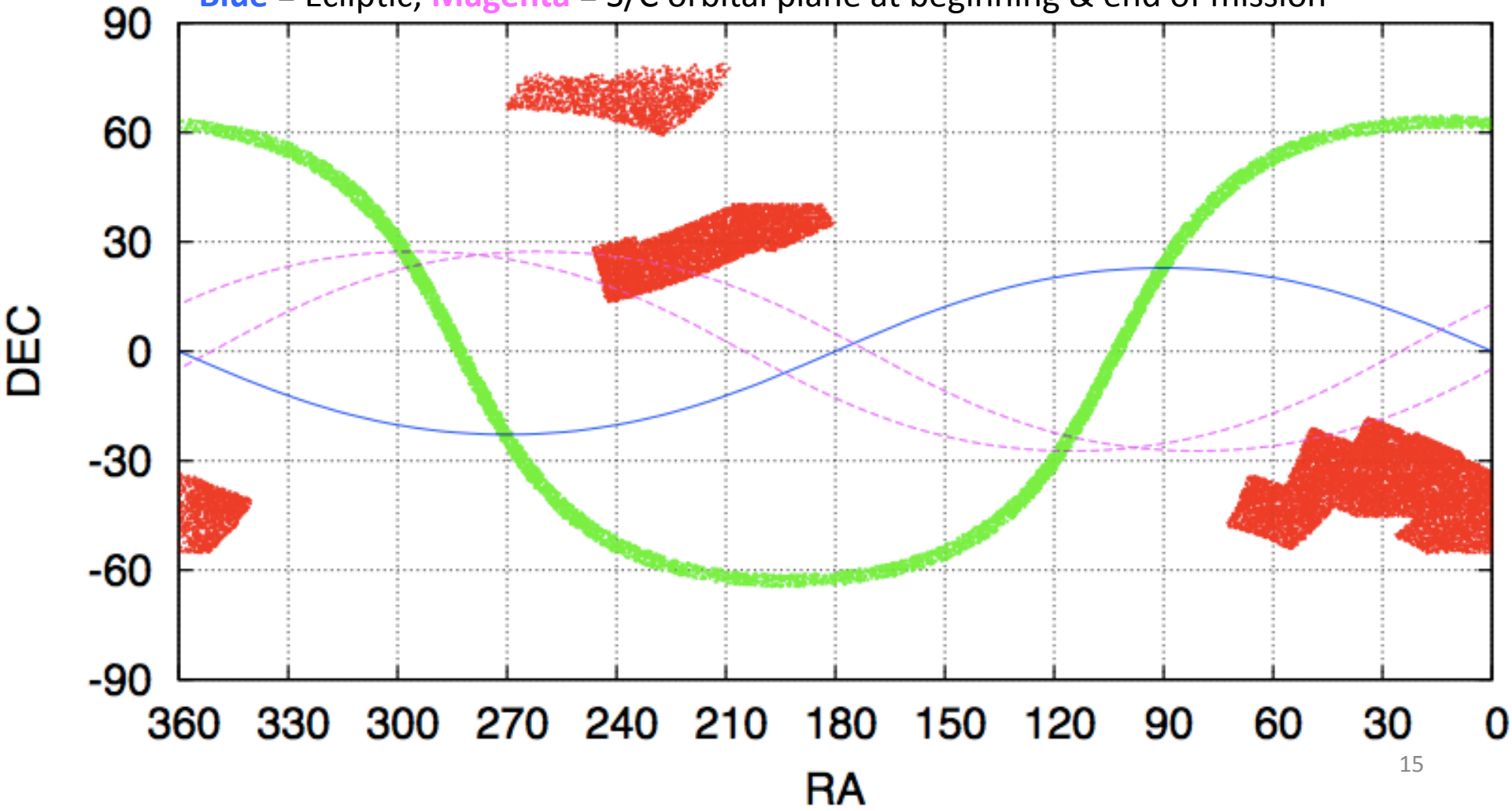
5 days

Wide Survey Footprint

Random Catalog [Red = HLS, Green = GP]

HLS Area = 2331 deg^2 [YJHK + Sp], Gal. Plane = 1013 deg^2 [YJHK]

Blue = Ecliptic; **Magenta** = S/C orbital plane at beginning & end of mission

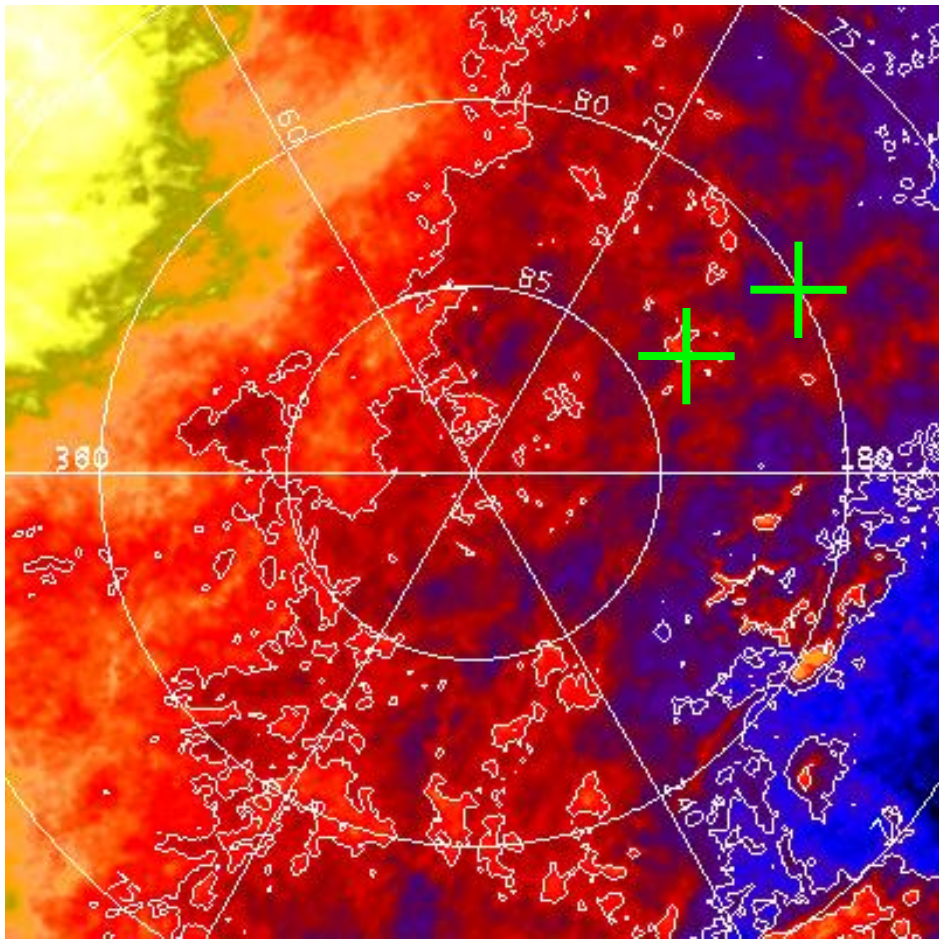


SN Field Options

Upper half of each panel gives easiest constraints from baseline GEO i=28.5° Ω~180°.

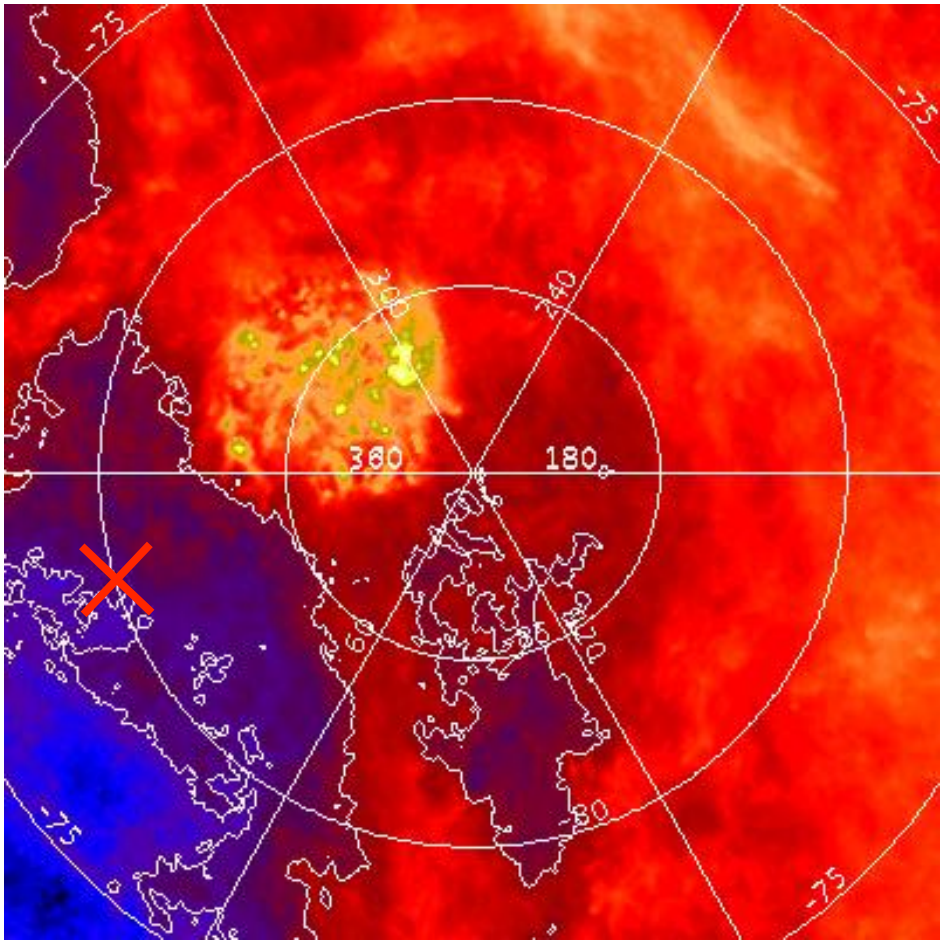
Figures from SkyView

NEP



Two field centers – biased toward Ecl +Y and away from Galactic Plane

SEP



Not in this plan but possible. Constraints: LMC avoidance, maybe R Doradus

Summary

```
# Number of observations      =   641573
# Beginning of sequence MJD   = 59608.104167
# End of sequence MJD         = 61405.971642
#
#
#    Microlensing                 337.713843 days
#    Supernova                    234.443217 days
#    Galactic Plane               147.812402 days
#    High Latitude Imaging        580.066436 days
#    High Latitude Spectroscopy   277.377243 days
#    Coronagraph                    0.000000 days
#    Unallocated                  212.179271 days
```

Note: This totals to 1790 days = 4.90 years due to accounting of “unallocated” time (I exclude a 180° slew at the beginning and end of each unallocated interval). The slew-settle time within each observing sequence is accounted for within that program.

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